SHOEMAKER

Motor Drive for a Wagon Factory

Electrical Engineering

B. S.

1914

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MOTOR DRIVE

FOR A

WAGON FACTORY

BY

FRED GLEN SHOEMAKER

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Fred Glen Shoemaker

ENTITLED Motor Drive for a Wagon Factory

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

E. Dana K. Waldo.
Instructor in Charge

APPROVED: Ellery B. Paine

HEAD OF DEPARTMENT OF Electrical Engineering

284641

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TABLE OF CONTENTS

I. INTRODUCTION 1

II. SOURCES OF OBTAINING DATA 1

III. DESCRIPTION OF PRESENT STEAM INSTALLATION 2

IV. CHANGES NECESSARY FOR MOTOR DRIVE 4

V. DISCUSSION OF CALCULATED RESULTS 6

VI. CONCLUSIONS 9

VII. DATA AND DIAGRAMS 13

Table 1. List of machines and H.P. Motors required 14

2. List of Motors and Cost of same. 23

3. Price list of Motors. 25

4. Cost of Engines, Boilers, Shafting, Pulleys,etc. 27

5. Data on Similar Installations 33

6. Results of Engine Tests 38

7. Calculated Results. 46

Diagrams.

1. General Layout of Buildings. 51

2. Location of Machines & Shafting. Wagon Dept. 52

3. " " " " " Box Dept. 53

4. Load curves from Engine Tests. 54

5. Yearly Cost of Energy. 55

Motor Drive for A Wagon Factory

I Introduction

The factory of the Abingdon Wagon Company is located in Abingdon, Illinois, a little town of about 3000 inhabitants in the western part of the state. While employed there as engineer the problem of motor drive suggested itself, and it is the discussion of this problem with which this thesis is to deal.

It was first thought that tests would be run on each machine to determine the proper size and speed of the motors required, but the limited time which could be given to this work and the trouble and expense involved, permitted only such tests as could be made during the regular operation of the plant. The company was very generous in allowing free access to their books and records and gave all possible assistance in making the tests and obtaining the data.

II Sources of Obtaining Data

There were three principal sources from which the data was obtained: the books and records in the company's office, actual tests of the machines, and records of similar installations published in current engineering magazines and in bulletins from motor manufacturers.

From the books of the company were obtained the present operating costs and the value of the boilers, engines, belts, shafting, etc., as they appear in the estimate.

The average indicated horsepower load of the machines was obtained by means of an indicator on the engines, the results

of these tests being shown in table number 6 and diagram number 4. Owing to the fact that these engine tests could not be applied to each machine separately and owing to the lack of time and facilities to make individual tests with a rated motor, it was found necessary to estimate the size of the motors required from data on similar installations. Part of this data is shown in table number 5. For those machines where no similar installations could be found, the size of the motor required was estimated from the speed and size of the driving belt, and these results compared with installations which have been made on machines of as nearly the same type and size as could be found. This being purely a case of selecting the motor by approximation, the various reasons and assumptions made would be of little value and hence the results only are given.

III Description of Present Steam Installation

The output of the plant consists of ordinary farm wagons and wagon boxes. During the growth of the business it was found necessary to extend the plant, and to do this the manufacture of the wagon boxes was assigned to a separate building using the old engines and boilers, and a larger steam plant was installed in the wagon department. The general layout of the building is shown in diagram 1.

The engines in each department are belted to the main line shafts as shown in diagram numbers 2 and 3, the machines being grouped conveniently along the line shafts and driven in most cases from overhead countershafts. This involves a large amount of shafting and belting and a friction load much greater than the

actual load of the machines. The engines are of the plain slide valve type, exhausting into a long trench-like cistern which serves both as a heater and a storage for water, the cistern for each plant holding enough water to run about ten hours. The engine and boilers at the Box department are quite old and of very little value. The power plant of the Wagon department is the newer installation and is in very good condition, although the the engine is very poorly designed and causes some trouble from worn rings and eccentric rods. Heat in winter is supplied by the exhaust steam from the engines or live steam from the boilers, and the dry kilns are heated by live steam exclusively. Light during working hours is provided by a 10 k.w. D.C. generator and from the service wires during the night or when shut down. The specifications of these boilers and engines are given in table number 4.

The stock in passing thru the factory is worked up in lots of convenient size, each operation being finished before going to the next machine, and hence any one machine is operated only a small part of the time during the day. The shaving exhaust fans are the only exception, as they operate continuously at from half to full load according to the number of machines being operated.

The present routing of the stock as it passes through the factory is fairly satisfactory, and the idea of two separate departments for the wagons and boxes with the warehouse in the center prevents confusion of the materials and permits the manufacture of each product separately.

The policy of the managers is to operate steadily the year round without much change in the number of men employed and to allow the finished product to accumulate in the warehouse during the dull season. This assures the men steady employment and is the means of keeping a force of trained employees at the minimum cost for labor.

IV Changes Necessary For Motor Drive

In the application of electric motors to the driving of woodworking and machine tools which operate under conditions such as are found in a factory of this kind, the requirements are so varied that the proper installation in any given case can only be determined by carefully studying all the conditions to be met.

There are four principal uses for energy in this plant which must be supplied with any type of drive: heat, for the buildings in winter, heat for the dry kilns, power to drive the machines and light.

The two 90-horsepower boilers in the power plant of the wagon department would be sufficient to furnish all the steam needed the year round, only one boiler being operated at a time. No data was available on the amount of steam used in the dry kilns, except that during the night sufficient steam was produced with the fires banked to keep them heated to normal temperature. This would indicate that the amount of steam necessary for the kilns is comparatively small.

Three phase squirrel cage induction motors are well adapted to driving such machines as occur in this plant, and owing to their high speed and rugged construction, they may be

placed close to the machine which they are to operate and drive directly by means of a flexible coupling to the counter shaft, or a very short belt. No starting compensator is required on motors under five horsepower, which are connected to machines such as wood working tools, that have little inertia in their moving parts and start practically without load.

In estimating the equipment for individual motor drive, each machine has its own motor, thus eliminating all the main drive belts from the line shafts, most of the counter shafts, and all the line shafts and pulleys.

With group drive only those machines were grouped together which require comparatively small amounts of power and are operated successively as the stock is passed from one to the other. These groups were selected by consulting the foreman of the shop and by observing the operations as carried on by the workmen.

Power for the motors and for lighting could be obtained from the Abingdon Light and Power Company, which now operates as a substation receiving power from the central station at Galesburg, Illinois.

The line shafts, pulleys, belts, etc. would have to be removed and the engines and the boilers from the box department torn down and removed. Some changes would also be necessary in order to connect the heating system and dry kiln of the box department to the boilers at the wagon department.

The motors would be installed on the floor close to the machine wherever possible, or overhead on the counter shaft in

such machines as require two or more driving belts, such as the large surfacers.

V Discussion of Calculated Results

The results as calculated in table No. 7 are primarily to be used as a basis for comparing the costs of power for individual and for combination motor drive with that of the present steam plant, and hence only the items which would be affected by changing to motor drive are considered. Results that are consistent in all three cases are aimed at, rather than the absolute determination of all the items which may be charged against the cost of power. The items will be discussed in the order in which they appear in the table.

The costs of labor, oil, waste, repairs, etc. as given in table No. 7, were taken from the books of the company and are the actual figures for 1913. The cost of the coal was so much per car at the mines plus the freight, which was not entered in the fuel account and was estimated by the manager at $55 for a 50-ton car and $25 for a 30 ton car. The costs including installation of the engines, boilers, pumps, shafting, pulleys, belts, etc. were taken from the estimate made by the American Appraisal Company of Chicago in 1912. The only material changes since that time have been the addition of clutches in the line shafts to safeguard the employees, and the shifting of a few machines from one position to another.

The cost of the motors was calculated from the list price as given in the 1913 catalog of the Central Electric Company. These prices are somewhat higher than those quoted by several

other firms and are assumed to cover the cost of installation. Since a large proportion of the motors would be located on the floor near the machines and would require very little labor to install, a discount of 10% on the total cost as figured above was considered ample to cover the cost of installation. The wiring installed, was estimated at $250 per outlet, which is no doubt more than the actual installation would cost as the circuits would be run overhead and down the posts to the motors without any inconvenience in installing.

The cost of the motor attendant and fireman was estimated at $650, the amount paid to each engineer at the present time. It is very probable that this would more than cover the expenses for this item when combination drive is used, as the number of motors is thereby reduced from 90 to 46.

The repairs on the motors and wiring were assumed to be 2% of the cost, and belt repairs at 4%, since no data was found on the subject. These items are comparatively small, and hence an error of a few percent is of little consequence.

The rate of interest was taken at 6% on the capital invested and depreciation according to the rates given by R. H. Fernald.

The value of the machinery which may be discarded when motor drive is installed is a problem which can only be estimated roughly. No data was available on this subject, and the values as given are simply assumed on the basis of the intimate knowledge which the writer has with the conditions existing in the factory. By noting the distance of the machines from the

lino shafts, the amount of belts that would be necessary with individual drive was estimated at 25% of the present installation, and 35% with combination drive. These are no doubt very generous estimates as the belts from the counter shafts to the machines are much smaller than those from the line shafts to the counter shafts. All the shafting and pulleys would be discarded with individual drive, and it was estimated that 80% would be discarded with combination drive. The countershafts are not listed with the lineshafts, but come as part of the equipment of each machine. The value of the belts was taken at their present depreciated value, it being assumed that the total value of the belts remains constant. The life of each belt was taken as seven years according to depreciation tables by Fernald, as above stated. The value of the discarded boilers and engines was assumed as scrap value at 5% of the total cost installed. In each of the above instances, the scrap value was taken as the net value after the cost of removal had been deducted.

In order to obtain the net charge with motor drive the interest at 6% on the value of the discarded equipment was subtracted from the gross charge. Taxes, insurance, office charges, etc., were assumed to be practically the same for each type of drive and hence did not need to be considered in this problem.

The average load of the machines in the whole factory throughout the year is a factor which is practically impossible to determine with any degree of accuracy except by continuous

records of some sort; therefore, no attempt has been made to do so. A very rough estimate of the load is sufficiently accurate for the results which are sought and therefore the maximum range of the average load was assumed to be between 20 h.p.and 65 h.p. Table No. 7 showing the yearly cost of energy for various loads and different prices per K.W.hr. is calculated for a range sufficiently wide to cover any conditions liable to occur in this problem.

VI Conclusions

In order to find a simple means of showing the results of the estimates for the cost of power with the different types of drive, the data was plotted in the form of curves as shown in diagram No. 5. The ordinates represent the yearly cost of power in dollars and the abscissae are cost of the energy in cents per K.W.hr. The yearly cost of power with various average loads is shown with the price per K.W.hr. ranging from one to four cents. The maximum allowable amount for energy with motor drive was taken as the difference between the total charge for power with steam drive and the charge for motor drive not including the cost of the energy.

Let us assume that the average yearly load is 35 H.P., and that the price of power is $.025 per K.W.hr. This load is about the mean of the results from the test and from the estimates. The price of energy as given is shown from the fact that the company was offered power at this rate only a short time before the tests were made. With these values of load and cost of energy

the net saving in cost of power with individual drive is $3700 and with combination drive $3800. These results are only true with the various assumptions that have been mentioned in making the estimate, but granting that there may be considerable error in some items , it is still evident that motor drive would show an appreciable saving in the operating expenses of the plant.

Considering that the present steam plant could produce an average load at the machine of 65 h.p. without any increase in operating expenses, it would still effect a considerable saving to install motors with power at $.025 per K.W.hr, and this rate could be increased to nearly $.04 per K.W.hr. before the operating expense would equal that assumed for steam drive. The installation of group drive, together with individual drive shows the largest saving and is probably the type of drive that would be installed.

There are many advantages with motor drive that cannot be capitalized at any definite amount, yet are none the less important in considering a problem of this kind.

The main object of any manufacturing plant is to obtain the maximum output at the minimum cost. In machines which operate intermittently the electric motor is the most efficient type of drive, as it consumes no power while the machine is idle and may be started and stopped frequently, thus saving power and the wear and tear on long lines of belts and shafting which are necessary with steam engine drive. Squirrel cage induction motors require practically no attention, except oil once or twice a month for the bearings and run at nearly constant speed

from no load to a considerable overload. The fact that they will carry heavy overloads for a short time without injury permits their use on machines such as swing cut-off saws, punches, mortising machines, and boring machines, with a rating much above the normal value for the motor. The routing of the stock as it passes through the factory is a very important item in the efficiency of production, and with motor drive the machines may be placed at any convenient point without regard to the location of line shafts or belts leading to other machines. A noticeable feature of steam engine driven factories is the great amount of shafting, pulleys, belts, and contershafts that are required to transmit the power to the machines. These not only require power, but they also shut off the light from above and take up a great amount of space. The liability of accident is large among belts and shafting, and such accidents are an appreciable expense, especially in plants using wood working machines. Belts are not only expensive,but are rather short lived and are the cause of frequent stops for tightening or repairs. With motor drive the belts would be reduced to a minimum thus eliminating losses due to frequent stops, slipping, etc. When power is bought from a large central station the service is practically continuous and this is an important factor in obtaining the highest rate of production.

In conclusion, the results of this investigation may be summed up as follows:

A considerable saving in the cost of power would be effected

by the installation of motor drive.

A combination of individual and group drive gives all the advantages of individual drive, with a fewer number of motors and a greater saving.

Due to the improved working condition, betterrouting of the stock, and freedom from breakdown, the rate of production could be increased materially without any increase in the size of the plant, or number of men employed.

VII DATA and DIAGRAMS

TABLE I

Machine number	Make and Description	H.P.Motor for Combination Drive	H.P.Motor for Individual Drive
20	Swing cut-off saw		
	J. A. Fay & Co.	3	3
21	Special wood frame saw table.	3	3
22	12" Buzz planer or joiner.		
	Superior Mc'h. Wks.	3	3
23	24" Single cylinder iron frame surface planer, will plane 6" thick.	7.5	7.5
24	12" Buzz planer and joiner,		
	J. A. FAY & Co.	3	3
25	Single cylinder surface planer to 6" thick.	7.5	7.5
26	Hollow chisel mortising mch. #161 chisel 6" stroke,		
	Bentel Margedant Co.	3	3
27	Combined wood frame saw table and boring machine.		3
28	Special wood frame saw (not in use) 24" and 30" saws		
29-30	2 Double spindle edge molding	5	5
	and shaping machines.	5	5
31	Post grind stone 10" x 2"		.5
33	Automatic Grinding Mch. wheel 21" x 1½".	.5	.5

34	Special wood frame saw table.		3
35	Double drum sanding machines.	5	5
36	Axle shoulder shaping machine,		
	Defiance Machine Works.		1
37	#4 Automatic skein setting and		
	fitting machine,		
	Union Foundry & Mch. Works		2
38	#5 Automatic skein setting and		
	fitting machine.	5	
	Union Foundry & Mch. Works.		2
39	#2½ Automatic skein setting		
	and fitting machine,		
	Williams White & Co.		2
47	30 ton hydraulic skein pressing machine.		1
40	#0 Vertical flexible belt		
	polishing machine.		1
41	Universal vertical boring machine,		
	16" swing.	7.5	
	J. A. Fay & Co.		1
42	Special Wood frame double sander.		5
43	12" New Improved buzz planer,		
	Superior Mch. Works.		3
44	Hub boring machine,		
	A. W. Barnard.		0.5
45	#2 single belt polishing machine.		1
46	Horizontal single spindle boring		
	machine.	2	2
48	Wood frame hub lathe,		
	16" swing, 11' 6" bed.		1

49	Wood turning lathe,		
	16" swing, 54" bed.		1
50	24" Iron frame surface planer,		
	will plane 6" thick.		3
51	Special single belt polishing mch.		1
52	Special single cylinder sander on		
	wood frame, 16" x 24" cylinder.	5	1
53	Horizontal single spindle boring		
	machine with attached counter shaft,		
	8" spindle feed.		
	Dennis Mch. Wks.		1
54	Improved felloe rounding mch.		
	Bentel Margedant Co.		2
55	42" x 60" wood frame saw table.		1
56	#0 Door sticking machine 4' x 16".		
	#17995 used as a hub planer.		
	J. A. Fay & Co.		3
57	#3 door and sash tenoning	5	
	mch., double cutters, double		
	copes.		
	J. A. Fay & Co.		3
58	Improved climax wheel tenoning		
	machine for wheels to 5' dia.		
	Bental Margedant Co.		3
59	#2 Automatic wheel		
	rimming machine,		
	Defiance machine works,	5	5
60	Spoke driving machine,		
	Hurlbut Mfg. Co.		2

61	Special 5 spindle tapping machine.		2
62	Special single drum sanding machine 24" x 9".	5	1
63	#2 spoke tenoning machine, double cutter single cope and cutting off attachment. Head 6" dia. will cut 3½" tenons on 6" timber. H. B. Smith Mfg. Co.		3
64	36" iron frame band saw, 36" x 2¼" iron wheels with rubber cover, 28" x 34" iron table.	3	3
137	(Milwaukee) 50" steel plate exhausting fan.	15	15
136	26" Surface planer, Witherbee Rugg & Richardson.	15	15

65	#3 Improved 80 ton low down iron frame hydraulic wheel press double pump, 5" adj. screw. Defiance Mch. Wks.	2	1
66	Iron frame belt driven beading roll, rolls 29/16" dia. 16" cap between housings.		2
67	Hydraulic hub bander, dies complete from $2\frac{1}{2}$ to $3\frac{1}{2}$" J. B. West.		1
68-69	2 20" swing upright drill press, W. R. & J. Barnes Co.		.5 .5
70a	12" swing upright drill press power spindle feed and self-contained cone counter shaft.	2	1 .5
71	Special wood frame power grindstone 32" x 6".		.5
72	Boss improved power Hammer. Head and die weigh 45#		1
73	Special heavy iron shears, 24" spurgear, crank feed, fly wheel.	5	5
74	#2 Spur-geared Bulldozer. Face of crosshead $34\frac{1}{2}$" x 6 3/4" 16" movement. Williams White & Co.	5	5
76	#3 Adams single head bolt cutter with counter shaft & pump. (Group with #80) Detrick & Harvey.	2	2

77	#3 spur-geared power press on cast iron legs. 2" stroke, 51" x 5½" fly wheel, Parker Bros.	3	3
78	#2 double power punching and shearing machine #901. 8" cut 7½" throat 28" x 7" fly wheels. Royersford Foundry & Mch. Co.	5	5
80	Iron frame tire bending machine rolls 5" x 6½". (Group with #76) Whitaker E. & S. Co.		2
81	#2 tire welding machine, Long & Alstath Co.		2
82	#3 hydraulic tire setter, takes wheels 30" to 57", 6" stroke to pumps. J. B. West.	2	2
83	#2 automatic wheel boxing machine, for wheels from 20" to 60". Defiance machine works.	20	20
84	#3 Cupola and forge blower. B. F. Sturtevant Co.	2	2
	Paint Shop.		
85	20" upright drill press. W. F. & J. Barnes Co.		1

86	McLinnen patent dipping tank #8330. 32" x 66" x 82" with agitator. Detroit White Lead Works.		.5
87	12" Wet paint grinding machine. John Lucas & Co.	1	1
88	Paint mixing tank on wrought iron legs. 18" 1826 tank with agitator.		.5
	Machine Shop.		
	90" swing 72" bed machine Lathe. American Mch. Co.	3	3
	Double emery grinding stand.		.5
111	New improved 36" band saw. Superior Machine Works.		3
112	Horizontal single spindle boring machine, 12" x 24" iron table, 8" spindle travel.	5	
	Superior Machine Works.		3
113	Combined 6 spindle wood frame tapping machine and 36" x 42" wood frame saw table, 14" saw.		3
114	New improved 8" buzz planer. Superior Machine Works.	3	3
115	New improved heavy column shaper. Two spindles on 26" centers.	5	5

116	Special 12 spindle tapping machine for 10" x 6" wagon box boards.		1
117	Special 12 spindle tapping machine for bottom box boards.		1
118	Special 10 spindle tapping	2	
	machine for tap side box boards.		1
119	Special 10 spindle tapping machine for 10" x 6" wagon box boards.		1
120	Flexible shaft tapping mch. with counter weight and friction drive.		.5
121	24" x 72" drum sander for box boards.	10	10
122	24 x 24" drum sander.		3
123	(Paint shop) Paint dipping tank		
124	with agitator.	.5	.5
125	Single spindle bench cover.	.5	.5
127	34" x 48" wood frame saw table, 2 - 18" rip saws.	7.5	7.5
128	20" upright drill press. W. R. & J. Barnes.	1	1
129	New improved swing cut-off saw. 18" saw. Superior Mch. Works.	3	3

130	36" Invincible triple drum surfacer, 8 roll power feed Berlin Machine Works.	25	25
131	Post grind Stone. (with 128)		
132	36" x 72" wood frame saw table, 18" saw.	5	5
133	New improved 28" cabinet planer for stock from 1/8" to 6½". Superior Machine Works.	7.5	7.5
134	40" x 60" wood frame saw table, 18" saws. Superior Machine Works.		5
137	45" Steel plate exhaust fan. Wm. Bailey & Sons Co.	10	10

TABLE 2

List of Motors.

Individual Drive				Group Drive.			
Wood Dept.							
No.	H.P.	List price	Cost	No.	H.P.	List price	Cost
3	.5	$36	$108	1	.5	$36	$36
14	1	45	630				
6	2	55	330	1	2	55	55
14	3	62	868	6	3	62	372
5	5	72	360	8	5	72	576
2	7.5	130	260	3	7.5	130	390
2	15	200	400	2	15	200	400
Blacksmith Dept.							
4	.5	$36	$144				
4	1	45	180				
6	2	55	330	4	2	$55	$220
1	3	62	62	1	3	62	62
3	5	72	216	3	5	72	216
1	20	230	230	1	20	230	230
Paint Department - wagons.							
2	.5	$36	$72				
2	1	45	90	1	1	$45	$45
Machine shop.							
1	.5	$36	$36				
1	3	62	62	1	3	$62	$62

Box Department.

3	.5	$36	$108	2	.5	$36	$72
5	1	45	225	1	2	55	55
7	3	62	434	3	3	62	186
3	5	72	216	3	5	72	216
2	7.6	130	260	2	7.5	130	260
2	10	155	310	2	10	155	310
1	25	270	270	1	25	270	270
90	304.5		$6201	46	248		$4033

Motor & Wiring.

90 outlets at $2.50	225	46 outlets at $2.50	115
	$6426		$4148

TABLE 3 Price List of Motors.

Prices for belt drive, sliding rails, starting compensator for motors above 5 H.P. From Central Electric Co., 1913.

Three Phase - squirrel cage, - induction motors.

Type	H.P.	Speed	Volts	List Price	
MA	.25	1200	110-220	$ 36	
"	.5	1800	" "	36	
"	.5	1200	" "	40	
"	1	1800	110-440	45	From electrical supply co.,
"	1	1200	" "	55	in St.Louis, Missouri.
"	2	1800	" "	55	$ 55.50
"	2	1200	" "	71	65
"	3	1800	" "	62	63
"	3	1200	" "	82	80
"	5	1800	" "	72	75
"	5	1200	" "	100	96
"	5	900	" "	130	125
"	7.5	1800	" "	130	128
"	7.5	1200	" "	170	133
"	7.5	900	" "	190	167
"	10	1800	" "	155	
"	10	1200	" "	195	164
"	10	900	" "	215	205
"	15	1800	" "	200	
"	15	1200	" "	230	205
"	15	900	" "	260	220
"	20	1800	" "	230	
"	20	1200	" "	270	228

Type	H.P.	Speed	Volts	List Price	
MA	20	900	110-440	300	251
"	25	1800	" "	270	361
"	25	1200	" "	295	378
"	25	900	" "	335	399

Equation for cost of polyphase induction squirrel cage motors from notes by A. A. Potter in "Power".

cost in dollars 116 + 4.75 H.P.

This equation is true only above 10 H.P.

TABLE 4 Cost of Power Plants, Shafting, etc.

From data by American Appraisal Co., Chicago, Ill.

Box Department.

110.	Frost Mfg. Co.	
	14" x 22" horizontal side	
	crank slide valve engine	
	box frame, fly ball governor	
	10" x 4½" x 4½" fly wheel	$700
	5' x 21" band wheel. Freight & inst.	80
		$780
100	2- J. T. Cullen (Clinton Ia)	
101	54" x 15' horizontal return tubular	
	boilers, 38 - 4" tubes, plain grates	
	full flush cast iron fronts, 30" x 30"	
	steam drums. Installed	$1950
102	1- Knowles steam pump	
	6 x 4 x 6 #128694. horizontal	
	duplex piston type steam pump.	90
	Freight & inst	9
		$99

Wagon Department

1-2	2- Frost Mfg. Co (Galesburg, Ill.)	
	60" x 18' horizontal return tubular	
	boilers, 46 4" tubes, half cast iron	
	front, shaking grates, butt joint double	
	riveted on horizontal seams.	
	Installed	$2300

#3 1- Knowles Steam Pump Works
6 x 4 x 6 #110923-4 horizontal
duplex piston type steam pump.
iron rods & lining Installed $99,00

#10 Frost Mfg. Co.
14 1/4" x 20" horizontal, side crank,
balanced slide valve, inertia governor.
84" x 24" fly and belt wheel.
Installed 1950

Shafting

Wagon Department

Engine Room		
#1 Shaft, collars, hangers.	$264.50	
Installation 35%	92.60	$357.10
Wood Dept.		
#1 continued	$280.62	
#10	76.41	
#11	36.73	
#12	22.70	
#13	12.50	
Installation 35%	150.21	$579.17
Blacksmith Dept.		
#11 continued	$81.21	
#14	16.92	
#15	16.16	
#16	9.00	
Installation at 35%	43.20	$166.49
Paint Dept.		
#11 continued	$16.96	
#16	12.80	
Installation at 35%	10.40	$40.16
Millwright work		
#1 Wagon Dept.	$93.84	
#10 " "	29.68	
#11	14.40	
#12	3.04	
#13	4.48	

#11 Blacksmith Dept.	25.28	
#14 " "	6.88	
#15 " "	6.24	$183.84
Outside Building		
#1 Shaft, collars, etc.	$38.00	
Installation	13.30	
Millwright work	10.40	$61.70
Total cost		$1388.46

Shafting

Box Department

Box Dept.		
#20	$171.66	
#21	143.15	
#22	5.69	
Installation at 35%	112.18	$432.68
Millwright work		
#20	$63.60	
#21	72.96	
#22	8.92	
Pulleys & idlers	58.00	$635.96
Total cost of installation in Box Dept.		$1068.64
Total cost of installation in both Depts.		$2457.10

Cost of materials alone - shafting, collars, hangers.

Wagon Dept.	$532.01	
Box Dept.	320.50	
Engine room	264.50	
Outside Building	38.00	
Total		$1155.01

Pulleys

Shaft #1	Engine room	$103.32
" #1	Wood Dept.	300.07
" #10	" "	181.45
" #11	Blacksmith Dept.	100.35
" #20	Box Dept.	178.23
" #21	" "	53.49
Total		$916.91

Belts

Engine room - installed	$379.61	
Wood Dept.	911.79	
Blacksmith Dept.	345.20	
Paint "	40.05	
Box	1080.84	
Total		$2757.49

TABLE 5 Name and size of Machine

HP		
15	Direct Connected	4 roll sander
10	" "	36" planer
5	Belted	2 spindle shaper
5	"	24" blower
5	"	Tenoning machine,- 36" band saw
5	"	Small sticker
5	"	30" jointer
5	"	Swing saw,- rip saw

Rockford Cedar Furniture Co. Rockford, Ill.

5	Belted	36" band saw
5	Line shaft	1- triple boring machine,- 1 tenoner,- 1 emery wheel,- 1 single spindle shaper
2	Belted	Belt sander
1	"	2 spindle boring machine
5	"	2 spindle shaper
5	"	Embossing machine,- 6 spindle adjustable boring machine,- reamer,- turning lathe
2	"	2 hydraulic presses
3	"	Buck shaper

Miscellaneous articles in Elec. Review.

10	Belted	28" planer,- #1 blower
15	"	42" sander,- #2 "
5	"	Two spindle shaper
1	"	Two spindle boring machine
3	"	Buck shaper

Hafner Furniture Co. Chicago, Ill.- sofas, couches.

20 48" Berlin triple drum sander

Wilmarth Show Case Co., Grand Rapids, Mich.

2 Belted to 36" band saw

3 " " single spindle shaper

3 " " 16" swing cut off saw

3 " " 12" jointer

7.5 " " 4 sided molder

5 " " 12" rip-saw

7.5 " " A Fay 24" single surfacer

2 " " Cut-off saw

Box Factory name not given.

5 Belted 16" rip-saw

3 " Cut-off saw

15 " 4 roll sander

15 " 36" planer and 36" jointer

3 " 16" cut-off saw

5 " 16" rip-saw

5 " 36" band saw and one jig saw

Rockford Superior Furniture Co., Rockford, Ill.

5 Line shaft 12" American belt sander,- 1 Beach jib saw,-
one Porter turning lathe,- 1 Fay shaper,- 1-36" band saw

7.5 Belted 30" blower

5 " 36" planer

3 Line shaft - 1 #2½ American horizontal boring machine,-
1 Dodd swing cut-off saw

3 Belted Jones #16 rip-saw,- 1 Fay & Egan 12" jointer

10 " 18" rip saw

7.5 " 30" drum sander

7.5	Belted	Double end cut-off saw
5	"	24" planer
5	"	16" hand jointer

The above taken from miscellaneous articles in the Western Electrician,(Electrical Review).

Data furnished by American Wood Working Machine Company, Rochester, New York.

Machine	Size	Vertical Cap.	Horizontal Cap.	HP
Band Saw	42"	20"	42"	3-4
" "	36"	16"	36"	2-4
" "	34"	12"	33.5"	1.5-3
" "	30"	12"	24"	1.5-3
Rip Saw	#2	24"	5"	5-10
" "	#3	16"	20"	7.5-15
" "	#6	30"	36"	10 - 20
Double Cut-off Saw	#2-3-4			5-10
Swing Saw, heavy				7.5-15
" " . medium				5-7.5
" " , light				3-5
Combination Saw & Dado	#7.5	21"	1"	4-7.5
" " " "	11-12	15"	4"	4-7.5
Vertical Borers	#1-2			3-5
Horizontal Boring Mch.	#1-2½			1-4.
Heavy Power Mortiser	#1			4-7.5
" " "	#2-3			3-5
" Bit "	#4			3-5
Heavy double door sticker	#6	18"	4"	5
Sash sticker	#3½			3-5
" "	#1			4-7.5
Two spindle shaper	#2½			3-7.5
" " "	#3			3-5

Tenoning machine	#1	20"	5½"	5-10
" "	#2½	15"	5½"	5-10
Column Sander	#9			2-5
Surface sanding machine	#15			1-3
Sand Belt	#5			1-3
" "	#8			1-3
3 drum sander	30"			10-20
" " "	60"x72"			15-25
" " "	30"x42"			25-35
One drum sander	30"x42"			7.5-15
Two drum sander	30"x42"			10-20
4 sided molder	#30		8"x4"	8-15
" " "	#1		6"x4"	5-10
3 " "	#1		8"x4"	5-75
2 " "	#1		6"x4"	4-5
1 " "	#1		6"x4"	3-5
6 roll planer & surfacer			24"x8"	15-25
4 roll double surfacer	#45		30"x8"	20-35
6 roll double surfacer	#51		30"x8"	15-25
Single surfacer	#5		24"x8"	5-10
Jointer & buzz planer	#1		8"x16"	3-5
" "	#1		30"x36"	5-7.5

TABLE 6

Engine Tests

Wagon Department Feb. 9-10 1914

Time	Speed	Area Head	Area Crank	M E P Head	M E P Crank	R Head	R Crank	Total I H P
8.00	193	2.28	1.93	27.25	21.87	55.10	72.85	97.95
8.05	195	1.88	1.59	22.46	18.78	45.90	37.10	85.00
8.10	197	1.96	1.62	23.41	19.58	48.30	38.70	87.00
15	195	1.99	1.60	23.80	19.12	48.50	37.70	86.20
20	192	2.10	1.63	25.10	19.49	50.40	37.90	88.30
25	186	1.39	1.90	16.60	22.72	32.28	42.80	75.08
30	183	1.95	2.19	20.30	26.18	74.60	48.40	93.00
35	187	1.77	2.05	21.18	24.50	41.40	46.40	87.80
40	186	1.58	1.87	18.89	22.38	36.70	42.10	78.80
45	185	1.71	1.93	20.42	23.06	39.70	43.25	82.95
50	188	1.69	1.77	20.20	21.18	39.70	40.30	80.00
55	186	1.58	1.58	18.9	20.06	36.75	37.74	74.49
9:00	184	1.60	1.75	19.12	20.92	36.80	38.95	75.75
05	186	1.50	1.68	17.92	20.06	34.85	37.80	72.65
10	187	1.71	1.80	20.42	21.54	39.90	40.70	80.60
15	185	1.63	1.86	19.48	22.21	37.70	41.65	79.35
20	186	1.56	1.98	16.52	23.64	32.15	44.60	76.75
25	187	1.66	1.98	19.85	23.64	38.80	44.80	83.70
30	186	1.65	1.77	19.72	21.18	38.32	39.90	78.22
35	183	1.70	1.72	20.32	20.58	38.82	38.15	76.97
40	186	1.62	1.68	19.37	20.06	37.60	37.82	75.42
45	187	1.64	1.76	19.60	21.02	38.30	39.82	78.12
50	184	1.85	1.94	22.1	23.2	40.65	43.2	83.85
55	184	1.68	1.85	20.06	22.10	38.60	41.15	79.75
10:00	183	1.82	2.03	21.77	24.28	41.60	46.45	86.05

05	186	1.64	1.70	19.6	20.35	38.1	37.3	75.40
10	190	1.74	1.78	20.80	21.28	41.40	41.00	82.40
15	184	1.78	1.86	21.28	22.23	41.00	41.45	82.45
20	188	1.68	1.96	20.06	23.40	39.40	44.60	84.00
25	191	1.55	1.95	18.53	23.32	37.00	45.10	82.10
30	188	1.51	1.90	18.05	22.70	35.48	43.25	78.73
35	189	1.50	1.81	17.92	21.64	35.41	41.50	76.91
40	190	1.63	1.71	19.48	20.42	38.70	39.35	78.05
45	190	1.60	1.69	19.12	20.20	38.00	38.85	77.85
50	189	1.70	1.89	20.32	22.60	40.10	43.30	83.40
55	188	1.74	1.84	20.80	22.00	40.90	41.80	82.90
1.00	189	1.55	1.62	18.02	19.38	36.60	37.10	73.70
11 05	190	1.64	1.66	19.60	19.84	39.00	38.20	77.20
10	181	1.80	1.75	21.54	20.94	40.80	38.20	79.00
15	187	1.69	1.69	20.20	20.20	39.50	38.30	77.80
20	186	1.70	1.72	20.32	20.58	39.58	38.72	78.30
25	189	1.78	1.70	21.27	20.32	42.10	38.90	81.00
30	189	1.95	1.75	22.10	20.92	38.10	40.01	78.11
35	189	1.61	1.59	19.23	19.00	38.02	36.40	74.42
40	188	1.58	1.68	19.00	20.08	37.40	39.65	77.05
45	188	1.54	1.55	18.40	18.52	36.21	35.35	71.56
50	188	1.67	1.61	19.98	19.24	39.30	36.70	76.00
55	190	1.56	1.68	18.65	20.08	37.08	38.64	75.72
12 00	195	1.35	1.46	15.13	17.45	30.15	34.50	67.65
1.00	192	1.31	1.62	15.64	19.38	38.90	37.70	76.60
.05	192	1.55	1.83	18.53	21.86	37.25	42.60	78.85
10	188	1.77	1.96	21.2	23.45	41.7	44.1	85.80
15	186	1.73	1.90	20.68	22.71	40.20	42.85	83.05

20	184	1.71	1.86	20.74	22.21	39.40	41.50	80.90
25	184	1.65	1.87	19.72	22.38	38.00	41.65	79.65
30	182	1.64	1.79	19.60	21.40	37.22	39.42	76.64
35	184	1.60	1.67	19.12	19.97	36.80	37.20	74.00
40	187	1.65	1.65	19.72	19.72	36.60	37.40	76.00
45	185	1.65	1.72	19.72	20.58	38.20	38.50	76.70
50	182	1.70	1.69	20.34	20.20	38.65	37.22	75.87
55	188	1.83	1.85	21.85	22.10	43.00	42.10	85.10
2 00	186	2.00	2.09	23.90	25.00	46.50	47.10	93.60
05	187	1.80	1.78	21.54	21.27	42.10	40.30	82.40
10	188	1.63	1.67	19.46	19.95	38.26	37.85	76.21
15	186	1.87	1.78	22.36	21.28	43.40	40.12	83.52
20	187	1.68	1.72	20.10	20.58	39.30	39.00	78.30
25	188	1.80	1.77	21.52	21.17	42.25	40.30	82.55
30	182	1.78	1.83	21.26	31.84	40.50	40.30	80.80
35	190	1.79	1.75	21.40	20.92	42.50	40.30	82.80
40	180	1.87	1.78	22.38	21.28	43.28	39.95	83.23
45	182	2.25	1.87	26.40	22.38	47.70	41.33	91.03
50	192	1.89	1.92	22.60	22.94	45.50	44.62	90.12
55	187	1.75	1.84	20.90	22.00	40.80	42.35	83.15
3 00	182	1.60	1.67	19.12	19.95	36.38	36.80	73.18
05	186	1.74	1.30	20.80	20.34	40.50	38.34	78.84
10	195	2.12	1.90	20.24	18.15	41.30	35.82	77.12
15	198	2.14	1.79	20.42	17.10	42.35	36.87	79.19
20	197	2.28	1.92	21.80	18.35	74.90	36.70	81.60
25	202	2.26	1.35	21.60	17.68	75.60	36.20	81.80
30	202	2.11	1.72	20.18	16.43	42.60	35.62	76.22
35	98	2.27	1.91	21.68	18.25	44.90	33.20	78.10

40	190	2.20	1.73	21.00	16.52	43.50	33.15	76.65
45	198	2.71	2.26	25.90	21.60	53.65	43.35	97.00
50	197	2.49	2.00	23.80	19.11	49.10	38.20	87.30
55	197	2.48	2.02	23.80	19.30	49.10	38.54	87.64
4:00	198	2.12	1.87	20.25	17.88	42.00	35.80	77.80
05	202	2.14	1.70	20.45	16.25	43.20	33.30	76.50
10	201	2.16	1.75	26.20	16.72	55.00	34.20	89.20
15	202	2.29	1.80	21.88	17.20	46.18	35.20	81.38
20	204	2.23	1.83	21.32	17.50	45.45	36.18	81.63
25	208	1.73	1.42	20.68	16.98	45.00	35.70	80.70
30	208	1.85	1.52	92.55	18.17	48.90	38.25	87.15
35	209	1.90	1.57	22.65	16.78	49.60	35.56	85.16
40	203	1.89	1.55	22.60	18.53	48.00	38.15	86.15
45	203	1.80	1.47	21.50	17.58	45.65	36.18	81.83
50	206	1.91	1.48	22.81	17.69	49.15	36.90	86.05
55	212	1.66	1.45	19.83	17.32	44.00	37.20	81.20
5:00	209	1.78	1.47	21.27	17.58	46.50	37.22	83.72
05	204	1.84	1.41	22.00	16.86	47.00	34.60	81.40
10	200	1.74	1.42	20.80	16.98	43.48	34.40	77.88
15	202	2.24	1.87	26.78	22.34	56.60	45.65	103.15
20	204	2.16	1.78	25.82	21.28	55.60	44.50	100.10
25	204	2.36	1.89	28.20	22.60	60.65	47.15	107.80
30	202	2.16	1.80	25.80	21.50	54.50	44.00	99.50
35	201	1.95	1.66	23.30	19.32	49.00	40.40	89.40
40	201	2.11	1.83	25.22	21.94	53.00	44.70	97.70
45	204	2.12	1.75	25.34	20.92	54.00	43.60	98.60
50	204	2.17	1.74	20.95	20.80	55.35	43.40	97.75
55	205	2.25	1.83	26.90	21.94	57.60	46.00	103.60
6:00	206	1.77	1.82	21.18	16.96	45.50	35.70	81.20

Average - 80.43

Engine alone.

192	.340	.540	4.06	6.45	8.15	12.5	20.65
192	.35	.59	4.19	7.05	8.40	13.7	22.10
192	.32	.57	3.83	6.81	7.69	13.22	20.99

Average 21.24

Engine - Exhaust fan - Line shaft.

191	1.28	1.39	15.41	16.60	30.80	32.08	62.84
190	1.35	1.38	16.15	16.50	32.10	31.70	63.80
191	1.27	1.39	15.20	16.60	30.35	32.10	62.45

Average 63.04

204	1.48	1.18	17.61	14.05	37.58	29.00	66.58
204	1.61	1.21	19.24	14.48	41.05	29.90	70.95
204	1.57	1.18	18.78	14.10	41.10	29.15	69.25
204	1.82	1.45	21.78	17.33	36.30	35.82	82.22 ?

Average 68.93

After 600 Lights on.

204	1.76	1.41	21.05	16.87	42.90	34.41	77.31
205	1.83	1.44	21.87	17.21	46.65	35.58	82.23

Average 79.77

Box Department

Time	Speed	Head	Crank	M E P Head	M E P Crank	Head	Crank	
8.30	128	1.84	2.00	12.06	13.09	13.2	14.02	27.22
35	128	1.80	2.04	12.08	13.39	13.20	14.32	27.52
40	131	1.82	1.96	11.92	12.86	13.38	14.10	27.48
45	129	1.78	2.02	11.68	13.24	12.80	14.30	27.20
50	128	1.76	1.99	11.53	13.05	12.62	13.98	26.60
55	128	1.72	1.89	11.29	12.40	12.33	13.28	25.61
9.00	128	1.74	1.95	11.41	12.80	12.49	13.70	26.19
05	126	1.85	2.09	12.12	13.71	13.10	14.46	27.56
10	128	1.81	2.04	11.88	13.39	12.99	14.32	27.31
15	130	1.85	2.03	12.12	13.50	13.50	14.45	27.95
20	129	1.67	1.86	10.95	12.20	12.08	13.06	25.16
25	129	1.75	1.88	11.48	12.99	12.65	14.01	26.66
30	128	1.74	1.94	11.41	12.72	12.49	13.62	26.11
35	128	1.83	2.01	11.88	13.18	13.12	14.10	27.22
40	130	1.60	1.82	10.50	11.92	11.67	12.98	24.65
45	128	1.61	1.84	10.57	12.08	11.55	12.92	24.47
50	129	1.84	2.01	12.08	13.19	13.31	14.22	27.53
55	129	1.81	1.85	11.83	12.79	13.05	13.80	26.85
10.00	131	1.63	1.83	10.69	12.00	11.97	13.15	25.12
05	130	1.63	1.83	10.69	12.00	11.87	13.04	24.91

Box Department

Individual Tests.

	Speed	Area Head	Area Crank					
	#130 Surfacer - Sander							
Idle	129	2.02	2.36	13.22	15.48	14.56	16.70	31.28
	129	2.05	2.36	13.44	15.48	14.82	16.70	31.52
	127	2.70	3.18	17.70	20.84	19.21	22.18	31.39
	127	2.85	3.10	18.70	20.35	20.30	21.80	42.10
	127	2.67	3.01	17.50	19.72	19.00	20.98	39.98
	127	2.74	3.05	17.97	20.00	19.50	21.22	40.72
	124	2.89	3.50	18.95	22.95	20.10	23.80	43.90
	124	3.52	3.86	23.08	25.42	24.50	26.40	50.92
	124	3.44	3.89	22.58	25.50	23.90	26.47	50.37
	124	3.41	3.46	22.37	22.68	23.70	23.56	47.26
	124	3.60	3.73	23.67	24.51	25.14	25.40	50.54
	#136 Planer							
	131	2.00	2.23	13.10	14.62	14.65	16.03	30.68
	131	1.89	2.23	12.39	14.62	13.85	16.03	29.88
	127	2.70	3.20	17.70	21.00	19.80	22.35	32.15
	127	2.91	3.20	19.10	21.00	21.36	22.35	43.73
	127	1.90	2.18	12.45	14.30	13.92	15.20	29.10
	127	2.45	2.82	16.08	18.50	14.20	19.68	33.88
	127	2.55	2.92	16.72	19.14	18.70	20.38	39.08
	127	2.51	2.84	16.50	19.32	18.48	21.18	39.66
	127	2.23	2.42	14.62	15.88	16.37	16.89	33.26

#137 - Exhaust fan

					x		
136	.95	1.14	6.24	7.50	7.41	8.53	15.94
136	.92	1.10	6.04	7.21	7.02	8.49	15.51
136	.95	1.10	6.24	7.21	7.25	8.49	15.74
136	.93	1.06	6.10	6.95	7.09	7.86	14.95

Average - 15.53

#110 - Engine alone - fan belt off.

136	.52	.61	3.41	4.00	3.96	4.52	8.48
136	.55	.63	3.61	4.14	4.20	4.68	8.88
136	.53	.64	3.78	4.20	4.05	4.75	8.80
136	.53	.67	3.81	4.40	4.42	4.98	9.40
136	.52	.58	3.42	3.81	3.98	4.34	8.32

Average - 8.77

#133 - Planer

128	2.12	2.30	13.90	15.07	15.22	16.12	31.34
130	2.14	2.41	14.03	15.80	15.61	17.18	32.79
130	2.24	2.40	14.70	15.75	16.34	17.12	33.46
128	1.91	2.10	12.52	13.78	13.70	14.73	28.43
128	2.00	2.19	13.12	14.38	14.38	15.38	29.76
128	2.00	2.16	13.12	14.18	14.38	15.18	29.56
127	2.26	2.45	14.82	16.08	16.12	17.10	33.20
127	2.20	2.49	14.42	16.33	15.70	17.39	33.09
127	2.10	2.44	13.80	16.05	15.01	17.03	32.04

TABLE 7

Steam Engine Drive

Coal	$4050.09	
Oil	211.16	
Grease	59.20	
Waste	22.42	
Engineer's Salary	1300.00	
Engine repairs	100.00	
Boiler compound	177.40	
Feed pump repairs	35.90	
Shafting & pulley repairs 3% on 3374.01	67.48	
Belt repairs - 4% on 2757.49	110.30	
Boiler repairs	100.00	
Packing	93.20	$6327.15

Interest & Depreciation

Belts	20% on	$2757.49,	$551.50	
Shafting & pulleys, etc.	10% "	3374.01	337.40	
Engine No. 10	14% "	1950.00	273.00	
Boilers, pumps, piping, etc.	16% "	2399.00	383.84	
Engine #110	14% "	780.00	109.20	
Boilers, pumps, piping, etc.	16% "	2049.00	327.84	
				$1982.78
Total Charge				$8309.93

Individual Motor Drive

Coal	10% (Of cost with steam drive)	$405.00	
Oil	25%	52 79	
Grease	25%	14.80	
Waste	25%	5.60	
Packing	10%	9.32	
Boiler compound	10%	17.74	
Feed pump repairs	30%	10.77	
Belt repairs	25%	27.57	
Boiler repairs	30%	30.00	
Motor and wiring repairs	2% of cost ($6426)	128.52	
Motor attendant and fireman (Same as steam engineer)		650.00	
			1352.11

Interest and depreciation:

Belts 20% on $689.37 (25% of present installation)	137.87	
Boilers, pumps, etc. 14% on $2399.00 (Boilers and pumps at Wagon Dept.)	383.84	
Motors, wiring, etc. 14% on $6426.00	899.64	
		1421.35

Value of discarded machinery:

	First Cost	Cost amt. Discarded	Present val. in %	1st cost	
Belts	$2757.49	$2068.11	57%	1178.82	
Engines & Boilers					
Engine #110 780					
" # 10 1950					
Boilers #110 1950					
Pump for #110 99	4779.00	4779.00	5%	238.95	
Shafting & Pulleys	3374.01		25%	843.50	
				2261.27	
					2773.46
Deduct interest on $2261.27 at 6%					135.67

Net charge not including cost of electrical energy $2637.79

Combination individual and group motor drive

Coal	10%	(Of cost with steam drive)	$405.00
Oil	25%		52.79
Grease	25%		14.80
Waste	25%		5.60
Packing	10%		9.32
Boiler compound	10%		17.74
Feed pump repairs	30%		10.77
Belt repairs	35%		38.60
Boiler repairs	30%		30.00
Motor and Wiring repairs	2%	of cost($4148.00)	82.96
Shafting repairs	2%	of cost($674.80)	13.60
Motor attendant and fireman(same as steam engineer)			650.00
			1331.18

Interest and Depreciation:

Belts 20% on 965.12 (35% present installation),	193.02
Boilers,pumps,piping,etc.16% on 2399.00	383.84
Motors and wiring, 14% on 4148.00	680.72
Shafting,pulleys,etc.10% on 674.80(20% pres.install'n)	67.48
	1325.06

Value of Discarded machinery:

	First Cost	Cost Amt. Discarded	Pres't.val. in %	1st cost
Belts	2757.49	1792.37(65%)	57%	1021.65
Engines, boilers,etc.	4779.00	4779.00	5%	238.95
Shafting,pulleys, etc.	3374.01	2699.21(80%)	25%	674.80
				1935.40
				2656.24
Deduct interest at 6% on $1935.40				116.12
				2540.12

Estimated Average Load

Foster gives the following data:

		Total No. Installations	Connected motor Load, Times average Load
Carriage works	Group	22	35.4
Machine shops	Group	51	34.5
Blacksmith Shops	Group	12	34.2
Wood working shops	Group & Ind.	64	34.4
	Average		34.4

Applying this constant to the problem:

	Connected Load	Av.load without fans	Av.load with fans
Individual drive	304.5 H.P.	8.82	33.82
Combination drive	248.0 H.P.	7.20	32.20

Average load from Engine tests.

Wagon Dept.

Total average indicated horse power - 9 hrs.		80.43
" " " " friction load		49.40
Average load of machines and fan		31.03

Box Dept.

Total average indicated horsepower - 2 hrs.		26.60
" " " friction load		17.44
Average Load of machines and fan		9.16
Total average load in both departments		40.19

Estimate of yearly cost of power for various average loads and different prices per K.W.hr. Exhaust fans assumed to run continuously at full load of 25 H.P. 3000 working hrs. per year.

Price of power per K.W.hr.		.01	.02	.03	.04
" " " " H.P.yr.		22.38	44.76	67.14	89.52
Exhaust fans	25 HP	559.20	1119.00	1679.00	2240.00
Load of machines	10 "	223.80	447.00	671.40	895.20
	20 "	477;60	895.20	1342.80	1790.40
	30 "	671.40	1342.80	2013.40	2685.60
	40 "	995.20	1790.40	2695.60	3580.80
Total cost - machines and fans					
	35 "	783.00	1566.50	2350.40	3135.20
	45 "	1036.80	2014.20	3021.60	4030.40
	55 "	1230.60	2461.80	3692.40	4925.60
	65 "	1454.40	2909.40	4314.60	5820.80

Comparison of Power Costs.

Total cost of Power steam drive	$8309.93
" " " "less energy cost - individual drive	2637.79
" " " " " " " - combination drive	2540.12

Maximum allowable amounts for energy-individual drive	$5672.14
" " " " " Combination drive	5769.81

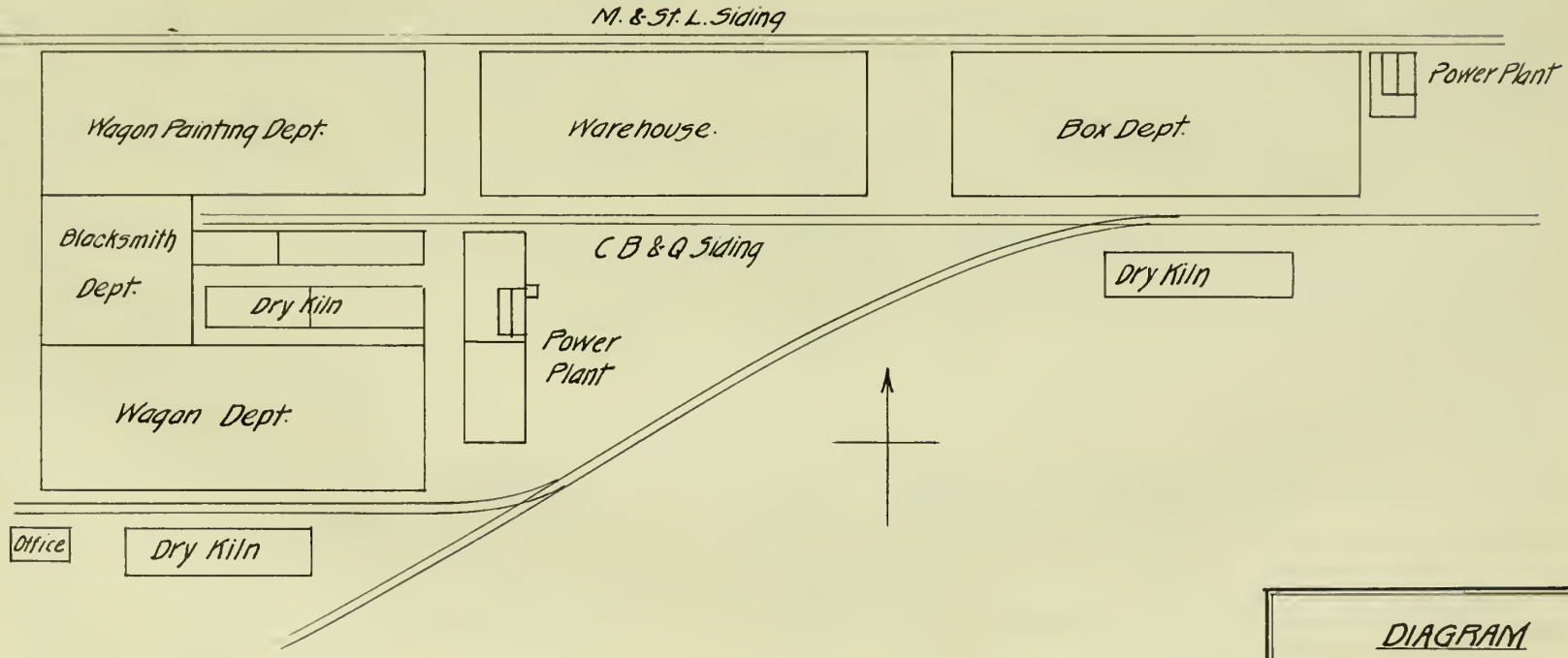
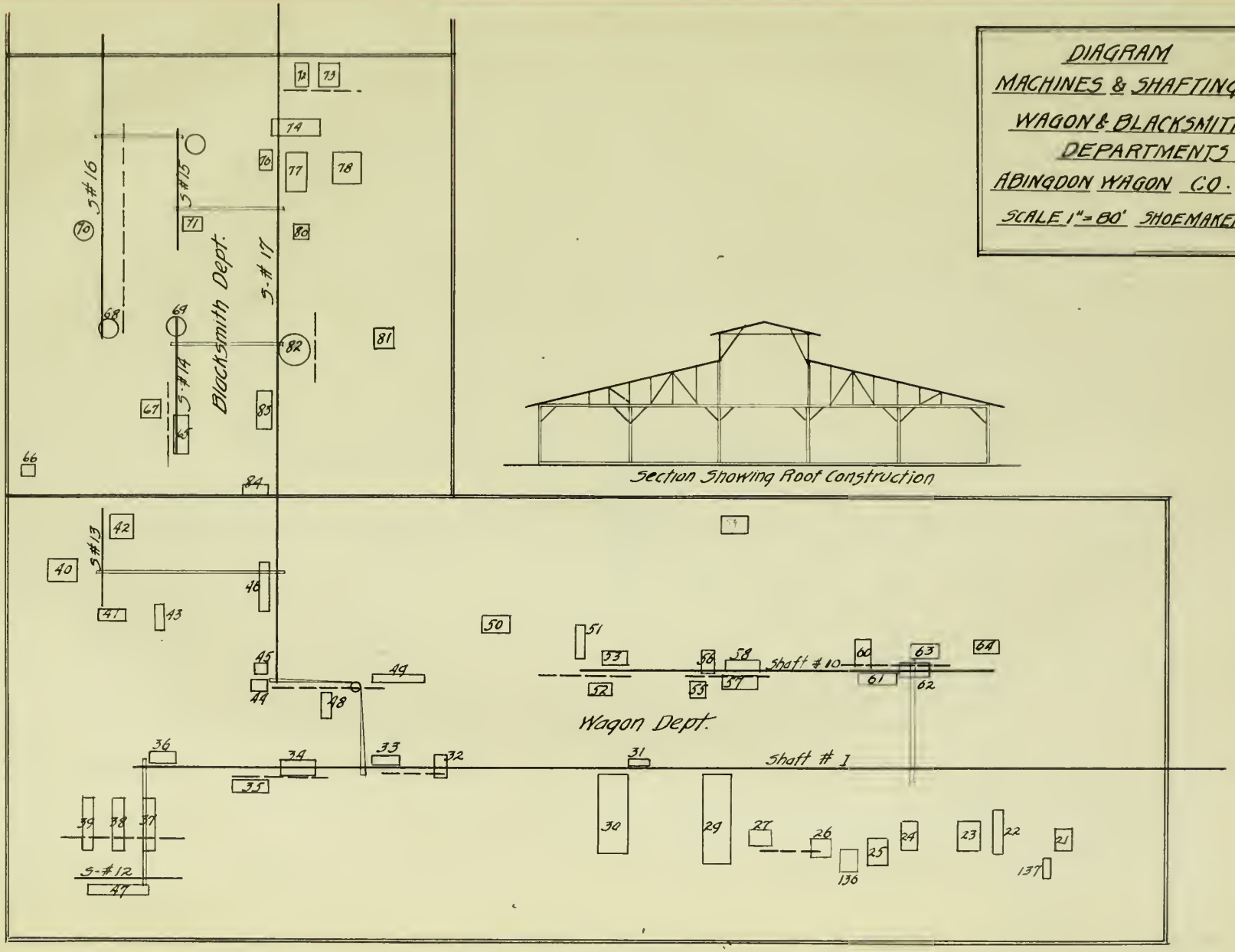


DIAGRAM
OF
BUILDINGS
ABINGDON WAGON CO.
SCALE 1"=100' SHOEMAKER, EG.

PLATE 1

DIAGRAM
MACHINES & SHAFTING
WAGON & BLACKSMITH DEPARTMENTS
ABINGDON WAGON CO.
SCALE 1" = 80' SHOEMAKER FG.



Section Showing Roof Construction

PLATE 2

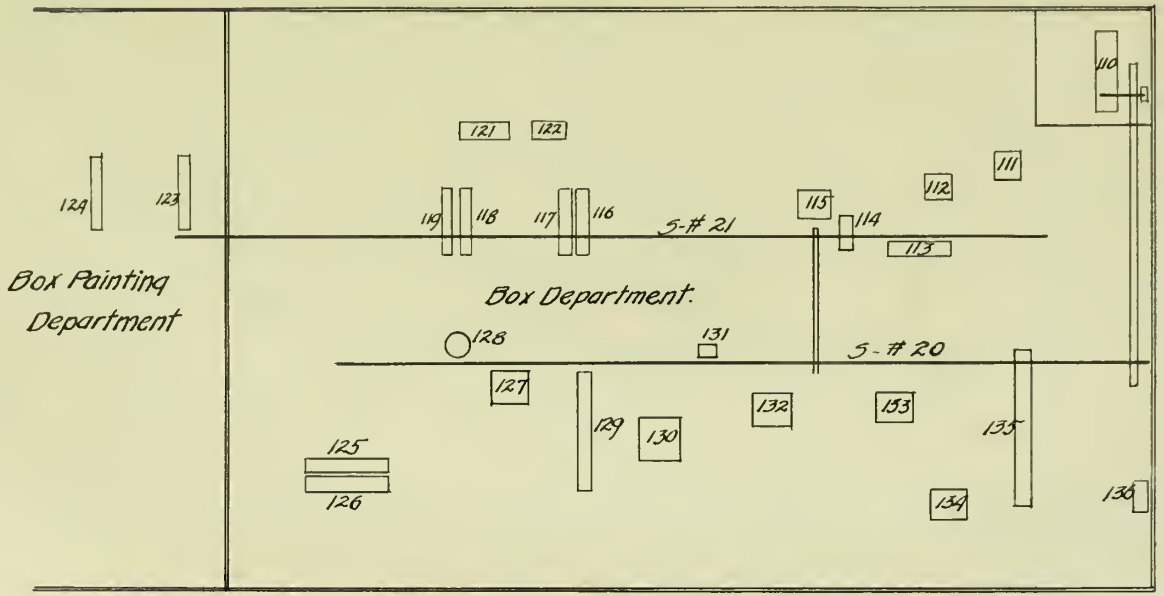
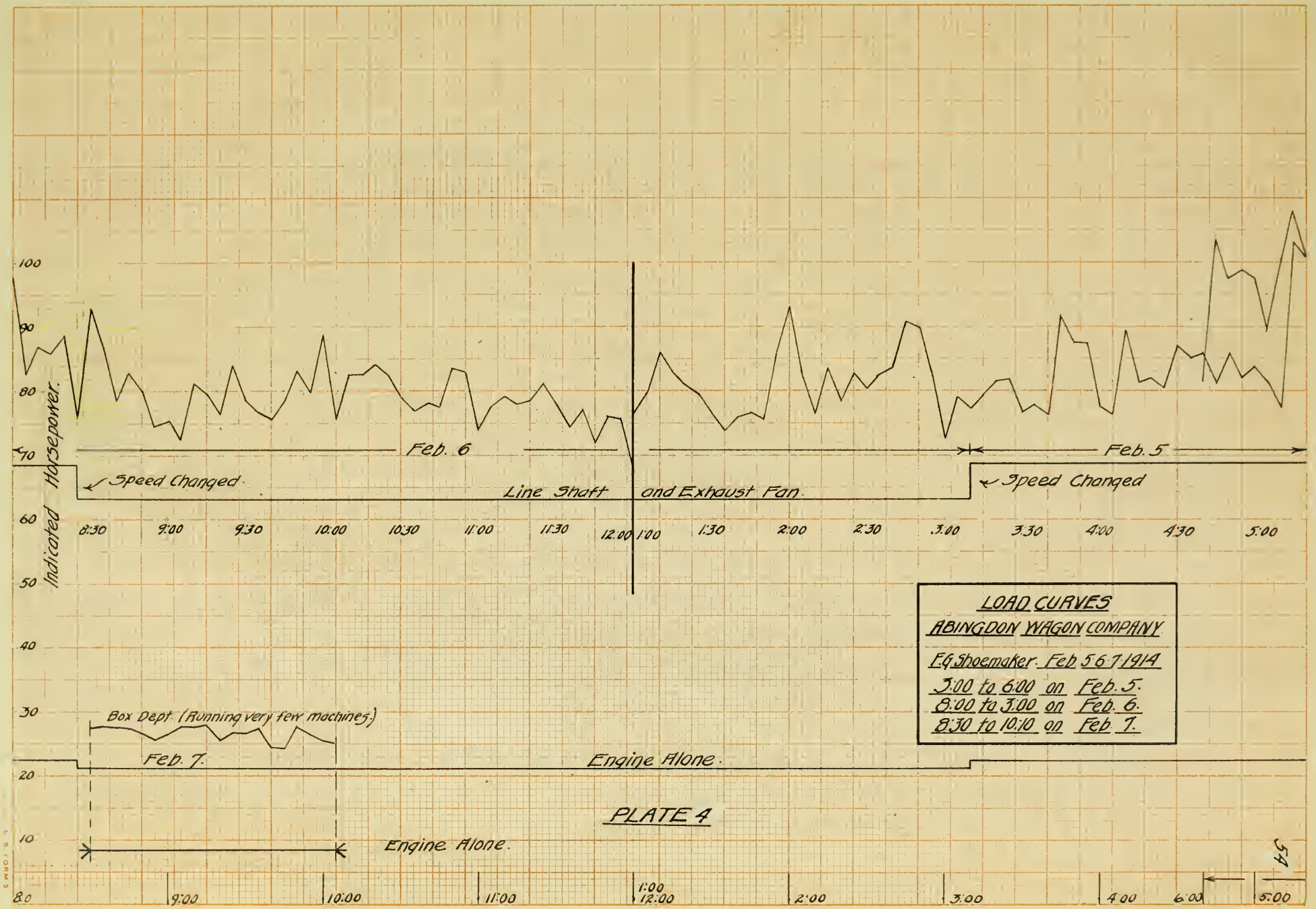


DIAGRAM
MACHINES & SHAFTING
BOX DEPARTMENT
ABINGDON WAGON CO.
SCALE 3"=80' SHOEMAKER, E.G.

PLATE 3


Indicated Horsepower.
100
90
80
70
60
50
40
30
20
10
0
Feb. 6
Feb. 5
Speed Changed
Line Shaft and Exhaust Fan.
Speed Changed
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
LOAD CURVES
ABINGDON WAGON COMPANY
F.G. Shoemaker. Feb 5 6 7 1914
3:00 to 6:00 on Feb. 5.
8:00 to 3:00 on Feb. 6.
8:30 to 10:10 on Feb. 7.
Box Dept. (Running very few machines.)
Feb. 7.
Engine Alone.
Engine Alone.
PLATE 4
9:00
10:00
11:00
12:00
1:00
2:00
3:00
4:00
5:00
6:00
54

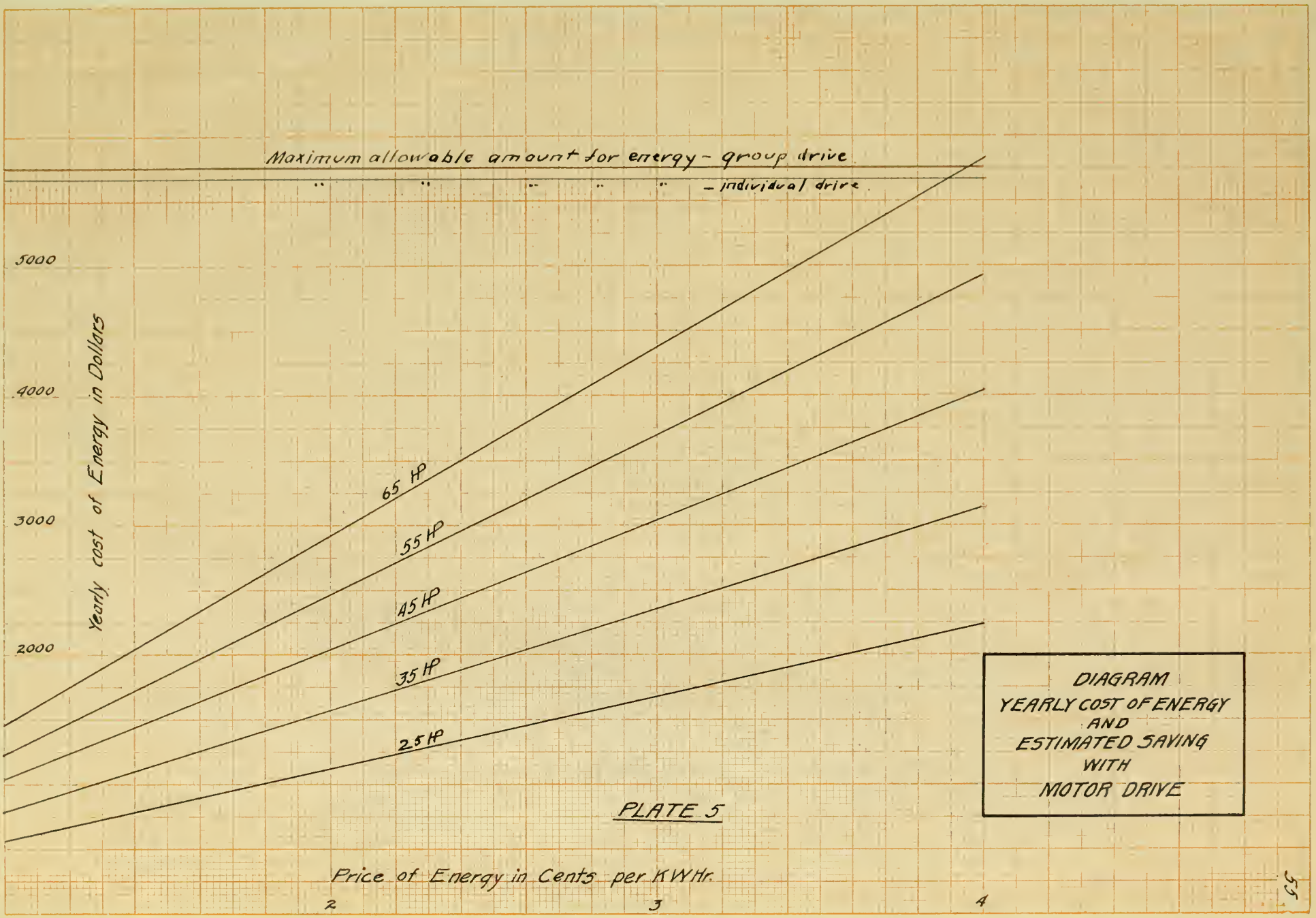


DIAGRAM
YEARLY COST OF ENERGY
AND
ESTIMATED SAVING
WITH
MOTOR DRIVE

PLATE 5

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